Status of the Terra Mission

Robert Wolfe, Kurt Thome, Si-Chee Tsay,

MODIS/VIIRS Science Team Meeting
November 19, 2019

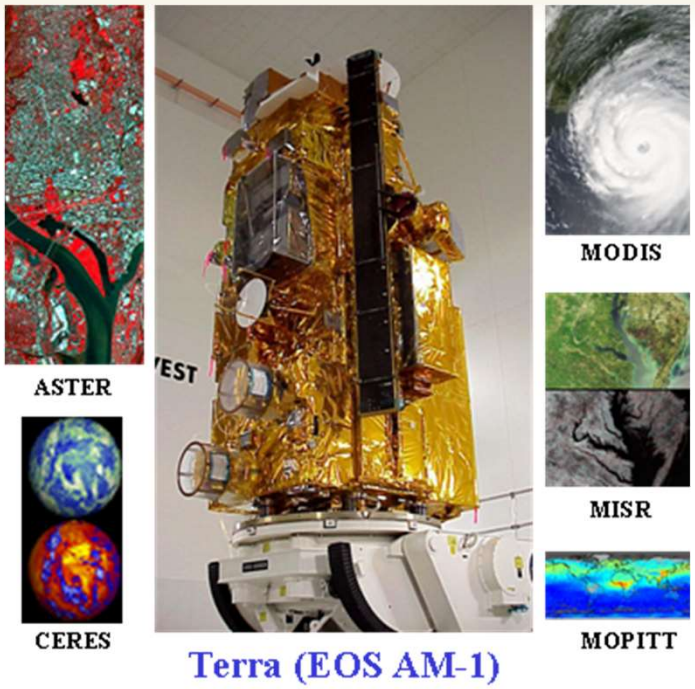
Terra team and sensors

- (GSFC)

Project Scientist (PS)	**Kurt Thome**
Deputy PS	**Si-Chee Tsay**
Deputy PS for Data	**Robert Wolfe**
ESMO Project Manager	**Wynn Watson**

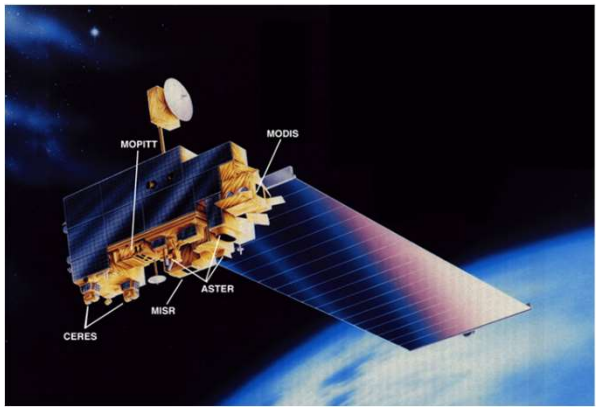
- Instrument PIs & Team Leaders (T.L.)

ASTER	Japan TL US TL	**Yasushi Yamaguchi** **Michael Abrams (JPL)**
CERES	PI	**Norman Loeb (LaRC)**
MISR	PI	**David Diner (JPL)**
MODIS	TL	**Michael King (UC/LASP)**
MOPITT	Canada PI US PI	**James Drummond (Dalhousie Univ.)** **Helen Worden (NCAR)**



- ASTER
  - Hi-resolution, multi-spectral images from 15 m to 90 m resolution, plus stereo
- CERES
  - Measures Earth's shortwave, longwave, and net radiant energy budget
- MISR
  - Global multiangle images of aerosol, cloud, and surface characteristics
- MODIS
  - 1-2 day global coverage in 36 wavelengths from 250 m to 1 km resolution
- MOPITT
  - Global measures of CO

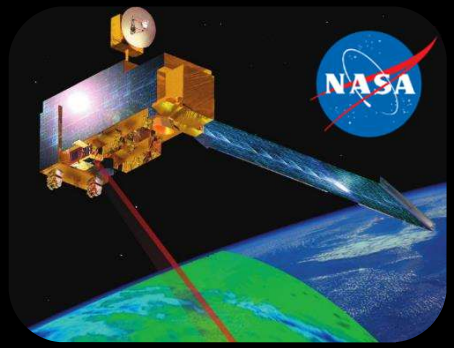
- Launch Date: December 18, 1999
- 705-km orbit
- 98.88 minute period
- 98.3 degree inclination
- 16 day repeat (233 orbits)
- 10:30 am crossing time descending orbit(originally 10:45 am)
- Design Life : 6 years
- AM constellation w/Landsat 7



The primary purpose of Terra is to enable the science community to address fundamental questions on causes and pace of global environmental change

TERRA

The Flagship Earth Observing Satellite



YEARS

19+

The NASA Terra satellite was launched on 18 Dec. 1999. Today, Terra continues to provide important data that builds on 19 years of climate data records.

ORBITS

100,000

Terra has performed over 100,000 sun-synchronous orbits around the Earth at an altitude of 705 km.

INSTRUMENTS

5

Terra has five instruments that collect data on Earth's atmosphere, climate, weather, carbon cycle, surface and interior, and water and energy cycles.

COUNTRIES

3

Terra is a multi-national satellite, carrying instruments from three international partners. The United States, Canada, and Japan work together to collect globally beneficial data.

DATA PRODUCTS

83

Terra's suite of instruments provide 83 core data products to the worldwide scientific community, making significant scientific contributions that advance our understanding of Earth's systems.

PUBLICATIONS

20,000

Over 20,000 journal articles using data from Terra's five instruments have been published by scientists worldwide.

RESEARCH

350,000

A total of 350,000 journal articles from around the globe cited work related to the Terra Mission, demonstrating the data's broad utility.

USERS

1,600,000

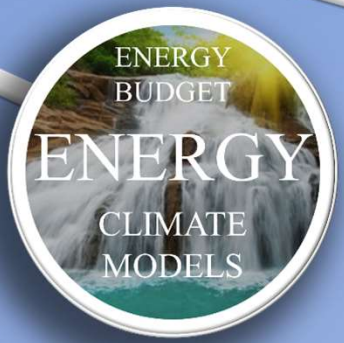
Terra data are being delivered to more than 1.6 million users around the world. The popular data has widespread applications and is easy to access. All of the data is free to users.

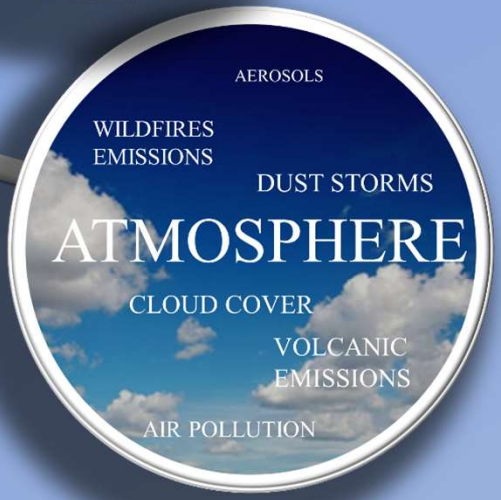
REAL TIME

240

Terra data is directly broadcasted to 240 stations worldwide with over 1,000 users in near real time (every 2.5 hours), and is delivered to DoD, NOAA, USDA and more.

SCIENCE AREAS
USING TERRA DATA





For nearly 20 years, the Terra mission has continually collected scientific data dedicated to understanding Earth's systems

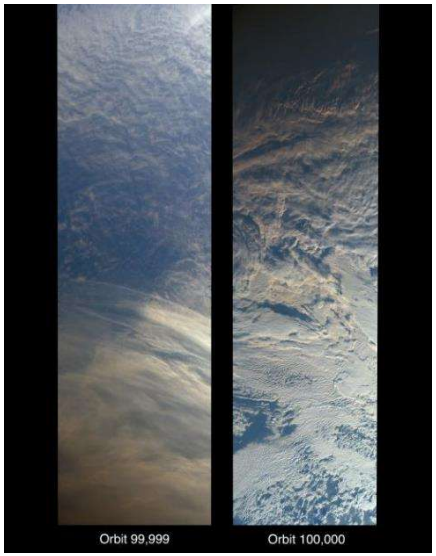
The size of the circles on the right represent the relative number of the 83 data products from Terra data in each science area

Terra's 100,000th orbit

- Opportunity to draw attention to the decades of dedicated work by the project's talented engineers and scientists
- Joins a handful of satellites to mark this orbit milestone, including the International Space Station, Landsat 5 and Landsat 7

Left is screenshot of Thomas Zurbuchen's tweet of the event

Right shows shows end of orbit 99,999 with MISR's 70-degree backward-looking camera followed by MISR's first view from orbit 100,000, taken with the 70-degree forward-looking camera



NASA scientists, engineers and designers pose in front of a full-sized model of Terra

"A well-built spacecraft, talented people running it and making great science products, with lots of people using the data, that's what has kept it running all these years."
Dimitrios Mantziaras, Terra Mission Director

Terra Team received the 2019 William T. Pecora Team Award

- Given in honor of Dr. William T. Pecora, Director of the USGS from from 1965-1971 and Under Secretary of the Interior
  - Motivating force behind establishment of civil remote sensing of the Earth from space
  - His vision and support helped establish what we know today as the Landsat satellite program
- NASA's Terra team was recognized with the 2019 group award for significant contributions in all areas of Earth science, with scientific impacts and a legacy that make it one of the most successful missions in NASA's long line of Earth Observing System satellites. The Terra satellite was launched in 1999 and continues to provide a wide range of global environmental observations.

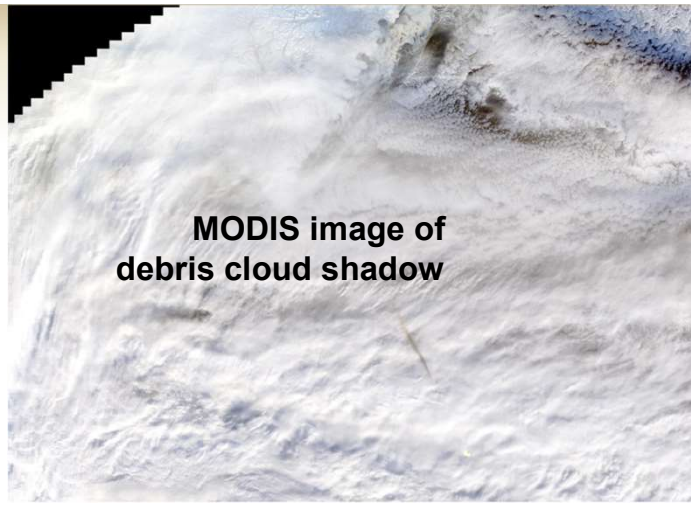
Attending the Oct. 7 awards ceremony were Michael Abrams, James Drummond, Robert Wolfe, Marie-Josee Bourassa, and Vince Salomonson

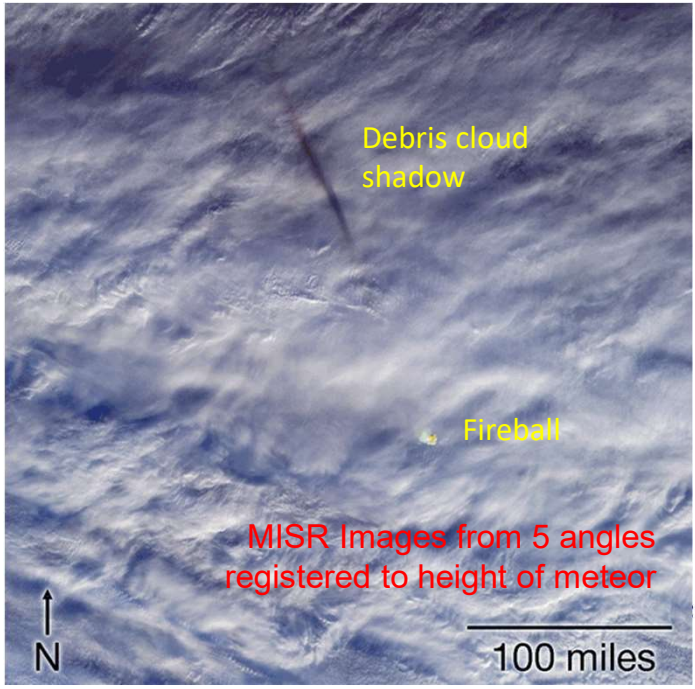
Terra at recent working group meeting in Boulder, CO September 2017

Terra and Planetary Science - Bering Sea Bolide

Dec. 18, 2018 "fireball" exploded above the Bering Sea

- The explosion unleashed ~173 kilotons of energy MISR stereo was used to calculate the height of the debris cloud: 28 km ASL
- Images obtained minutes after the event
- Terra scientists participated in the Planetary Defense Conference





SCIENCE 03/25/2019 11:44 am ET HUFFPOST

NASA Captured Images Of A Giant Meteor Explosion Over Earth

What does the future hold for Terra?

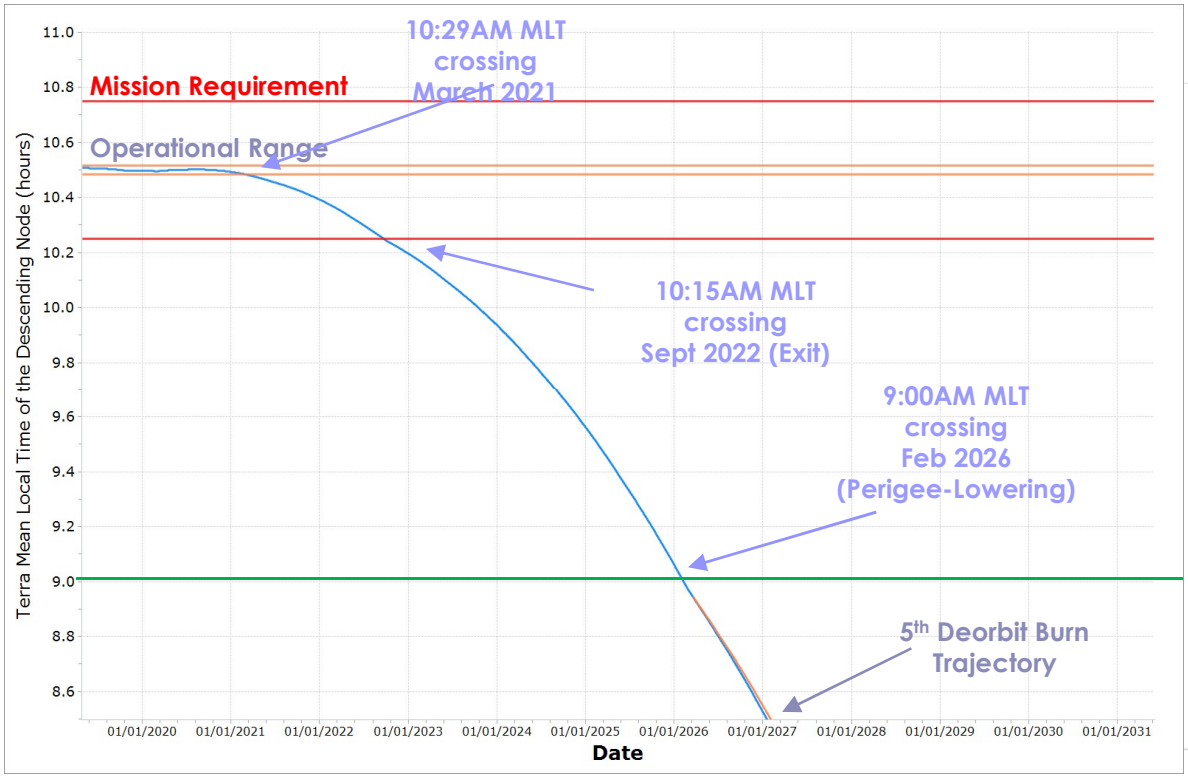
No known life-limiting hardware on Terra at this time

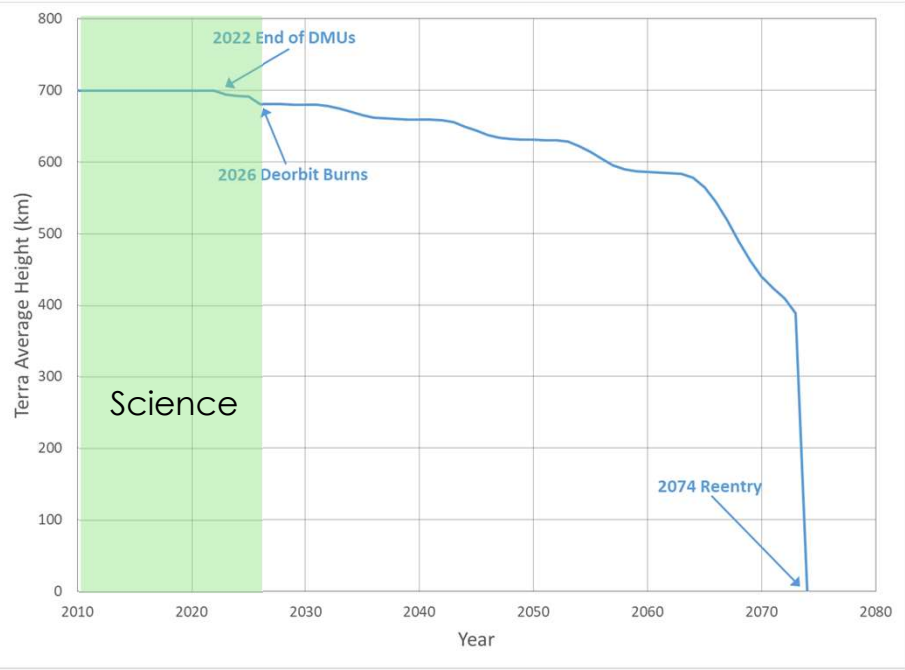
- Terra will continue operations at its current crossing time and altitude through the **last inclination burns** planned for **March 2020**
- Terra will begin drifting after its final inclination maneuvers
  - Crossing time will begin changing to an earlier time
  - 10:15 am is the current lower limit for Terra's operation
- Current plan is to **exit the 705-km constellation** when Terra's crossing time reaches 10:15 am currently predicted for **September 2022**
- After exit, Terra continues to drift in crossing time with altitude slowly decaying
  - 9:00 am crossing time is used as a placeholder based on passivation of EO-1
  - Current predictions are for Terra to reach **9:00 am crossing time in Spring 2026**
  - *Instruments on Terra can provide high-quality science data well beyond the 9:00 am crossing time*
- Remaining fuel used to lower perigee prior to spacecraft passivation

Maintain current crossing time through Spring 2020

Constellation exit assumed to be required when crossing time reaches 10:15 am

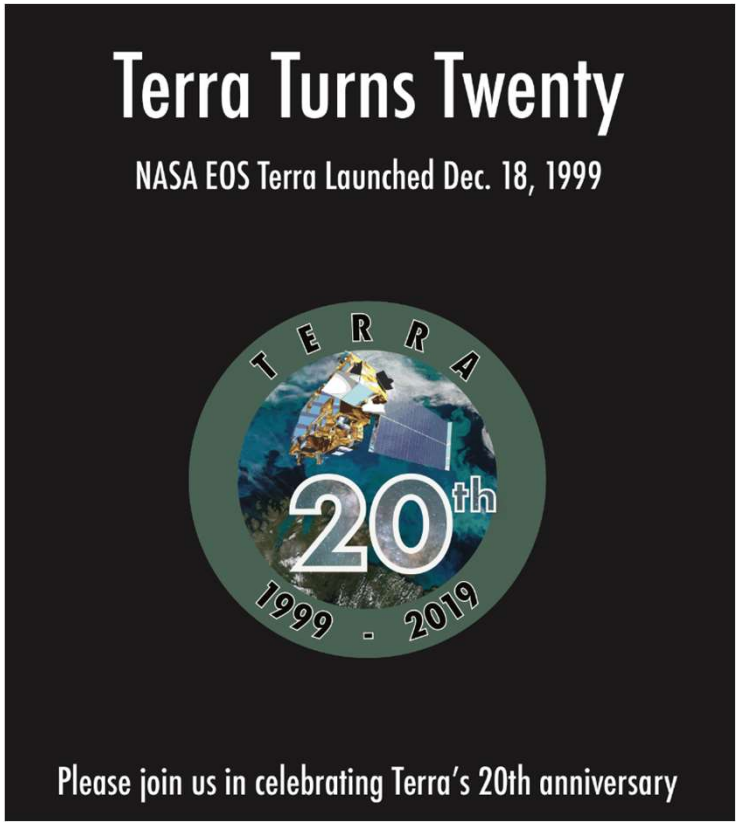
Passivation currently planned at 9 am crossing time (the EO-1 limit)





Decommissioning Plan	MLT Violation (10:29AM)	MLT Violation (10:15AM)	Exit Year	De-orbit Burns (#)	Apogee at Depletion (km)	Perigee at Depletion (km)	Crossing time 9:00AM MLT	EOM to Reentry (years)	Reentry Date
Baseline	**Mar 2021**	**Sept 2022**	**2022**	**5**	**691.1**	**667.0**	**2026**	**43**	**2069**

Terra@20 events



Events will take place in San Francisco during AGU the week of Dec. 8; GSFC the afternoon of Dec. 18; College Park the evening of Dec. 18; and Pasadena in February

- AGU
  - December 8, 2019 from 6-7 pm at the Marriott Union Square, Savoy Room
  - December 10 for no host dinner at Harry's Hunan
  - Two oral sessions and one poster session on Dec. 9
- GSFC
  - December 18, 2019
  - Building 33 Room H114
  - 3 – 5 pm
- College Park Holiday Inn
  - December 18, 2019
  - 6-9 pm
  - No host buffet dinner
- Pasadena
- February 2020
- Hosted by JPL as part of the MISR Science Team Meeting (Feb. 12-13)

2017 Senior Review

Senior Review Proposal is the place for making Terra's case for continued operation

- Science message is the primary basis for proposal evaluation
- 2017 was previous Senior Review
  - Terra and Aqua were again highly ranked
  - New feature was that the Terra/Aqua Algorithm Maintenance funding was included as part of the Senior Review Process
  - Terra's approach was that the project team members provided section inputs aligned with the different panels that evaluate the proposal
  - Added extra work for the MODIS and CERES leads who had to interpret further the inputs they received from their team members

2020 Senior Review Proposal

- Senior Review process is now on three-year centers
  - Reduces the work load somewhat
  - Increases the importance of an individual proposal
- Changes in 2020 versus 2017
  - Algorithm Maintenance support is being integrated into the project proposals
  - Current budget assumes that Terra/Aqua/Aura will begin Phase F process at end of FY22 and project closeout at end of FY25
- Terra's 2020 proposal approach will follow the 2017 proposal organization but ensure that the impact to society is made clear
  - Terra's Senior Review proposal will include a request for additional funding in FY23-FY25 to continue operating and not begin Phase F
  - Draft outline of Terra SR proposal and timeline for proposal development is planned to be done by 11/30

Terra continues to add to its 19-year legacy

Has met the original 18-year, planned data record for the three EOS AM platforms

- Terra data record at its current crossing time reached 18 years in Spring 2020
- Terra data continues to play a role as the baseline data set for comparisons for recent and future missions
  - S-NPP, NOAA-20
  - New Decadal Survey recommended measurements
  - Earth Venture missions
- Two decades on orbit takes a lot of effort
  - Result of an excellent set of engineers, scientists, programmatic personnel in the 1980s and 1990s to develop Terra
  - Teamwork by these same groups and periodically adding new and younger faces ensures Terra stays healthy and relevant